FLUKA study of beam loss monitors for SIS100: General diagnostics and quench prevention of superconducting magnets

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In view of the planned coverage of the synchrotron SIS100 with beam loss monitors (BLMs), FLUKA studies were performed aiming at two goals: to evaluate the sensitivity of these detectors to the expected beam losses at SIS100, and to estimate the BLM quench prevention thresholds via the correlation between the energy deposition inside the superconducting coils and the BLM active volume. A large number of ion species and energies were considered. The results of these studies, described in detail elsewhere [1], very much support the use of the BLMs for quench prevention (protection of magnets) via an interlock generation, as used at the LHC.

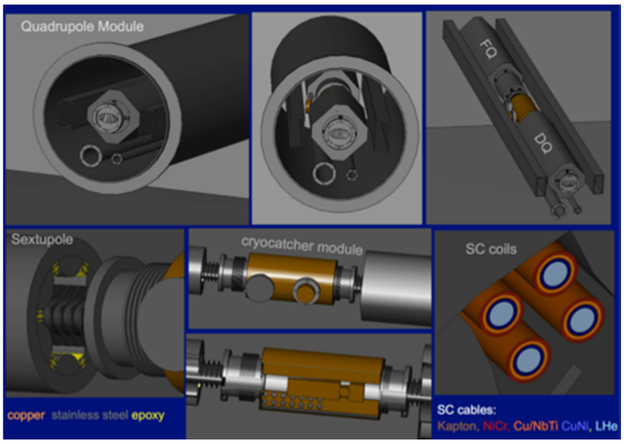

Figure 1: FLUKA geometry of a quadrupole module.

The goal as described required a precise modelling of the geometry of a SIS100 quadrupole module, the SIS100 extraction straight section and the SC coils including the cable details (Fig.1).The results on the response of the LHC-IC type BLMs to the beam losses within the warm quadrupole doublet of the SIS100 extraction straight section show a great sensitivity of these monitors. Instantaneous radiation caused by 0.1% beam loss at injection- and 0.0001% at extraction energy will be detected if BLMs are placed close to the source.

The different aspects of machine protection are usually based on a variety of systems. Quench prevention of SC magnets can only be ensured by a BLM system, the only active system in case of fast losses with time scales between 100 μs and 10 ms. While the total energy and therefore the overall damage potential is very much larger at the LHC, certain accidental scenarios can be equally severe at SIS100, due to the Z^2 dependence of the initial energy deposition. The responsible quantity for the quenching of SC coils is the local energy deposition, and as little as $1 mJ/cm^3$ quenches a magnet. Quenching would cause a downtime of more than hour, while real damage of a single magnet would cause much longer downtimes at very high costs. All this suggests that the protection of the SIS100 machine should also be strict.

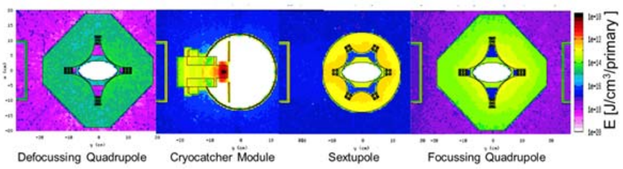

Figure 2: Energy deposition in the region of the SC coils.

The possibility of quench prevention of the SIS100 SC magnets by the planned BLM system has been studied with FLUKA simulations. As a representative example for

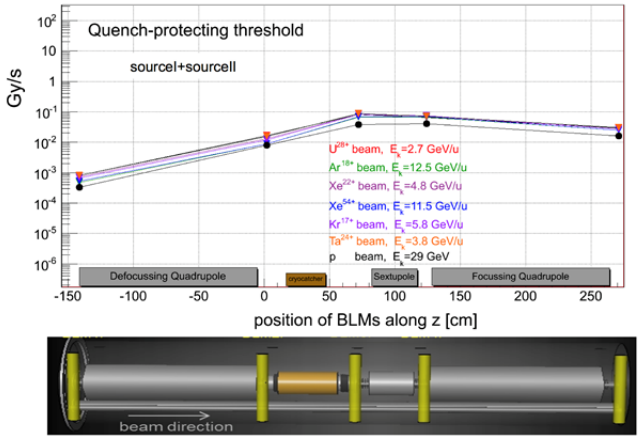

Figure 3: BLM quench prevention threshold along a quadrupole module for p and ions beams of different E.

a source of beam loss at SIS100, the losses due to charge exchange of U^{28+} beams were examined. The corresponding special distribution of the energy deposition within the individual components of a quadrupole module is shown in Fig.2. The LHC-IC type BLMs were found to be sensitive both to the quench prevention thresholds and to the loss rates expected due to these losses. In addition, a number of other ion species and energies including protons were considered to demonstrate a comparable sensitivity for all other beams to be accelerated with SIS100.

An interesting finding of this study (Fig.3) was that, for the same beam loss location, the quench-prevention thresholds were almost identical for all ion species/energies including protons. In the future, a systematic investigation of all possible failures at SIS100 is required to optimally integrate the BLM system into the beam interlock system.

References

[1] S. Damjanovic, EDMS Note, Document FAIR-1SBDX-ER-0001, Id 1473055 (2015).

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